An interactive tool to estimate Achilles tendon local strain using high-frequency ultrasound: preliminary results

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Introduction: Tendinopathies are among the most common musculoskeletal injuries. Nowadays, part of its diagnosis is established through subjective qualitative evaluation of 2D ultrasound (US). This enables limited diagnostic differentiation or therapeutic optimization and has limited added value to diagnosis in an earlier stage. It is generally accepted that extra diagnostic information can be obtained via strain evaluation. The accurate validation of strain estimation is challenging due to the lack of a ground-truth. Therefore we evaluate the repeatability of displacement and strain estimations in the longitudinal direction, using an easy, fast and interactive application to estimate local strain during dynamic loading of the tendon.

Materials and Methods: One healthy volunteer laid in a prone position with the foot fixed to an isokinetic device. Three sets of passive movement between −10° plantarflexion and +10° dorsiflexion were performed and repeated the following day. During this, US images with a spatial resolution of 0.02mm x 0.09mm were acquired at a frame-rate of 100Hz. The US system used was the Vevo2100 with a MS250 linear array transducer with a center frequency of 20MHz. After image collection, consecutive pairs of 2D images were registered in a multi-resolution scheme, using an affine and b-spline transformation optimized by the minimization of the sum-of-squared differences, to obtain deformation vector fields. Lastly the interactive application allows local analysis of tissue displacement and strain within selected regions of interest. Mean and standard deviation of the intra- and inter-day relative differences were calculated.

Results: The results show a mean intra-day relative difference of 13.71%±4.76% in displacement and of 16.29%±5.17% in strain. For inter-day comparison, the relative difference was 16.98%±14.62% in displacement and was 16%±13.51% in strain. Results show physiologically meaningful and similar strain tendencies when grouping proximal and distal regions.

Discussion: This work shows promising preliminary data that suggest that with our method strain and deformation can be measured in a reproducible way using high-frequency US, with little effect of slight variations in acquisition conditions. This brings the application of US based strain estimation in clinical scenarios closer to reality. However, further tests are needed to confirm these conclusions.